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LEVEL II

(1)

PRELIMINARY ANALYSIS OF TECHNICAL RISK AND  
COST UNCERTAINTY IN SELECTED DARPA PROGRAMS

⑦ Interim Progress Report  
⑪ 3d July 1981

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## I. SUMMARY

This Interim Progress Report summarizes work performed under Task 1, "Data Collection and Analysis," of the contract Statement of Work. The objective of the total effort is to explore options and provide recommendations for improving program management functions related to technical risk assessment and cost/schedule uncertainty for selected DARPA programs. The effort documented in this report includes an analysis of historical data related to government R&D program cost overruns and a preliminary assessment of the implications of such analysis for management reserves for related high-risk DARPA programs. This assessment will ultimately lead to the specification of a process to guide DARPA management in the establishment of budgetary reserves to account for technological risk and to periodically update projections of selected program cost growth based on experience. Such a procedure would not only benefit future DARPA program planning and control but is also responsive to the letter and spirit of recent recommendations to improve the acquisition process with the Department of Defense (DOD).

The key to the work performed so far under this contract is the establishment of a data base containing information on historical cost growth of major government R&D and production programs during the period FY 1977 through FY 1980. These programs include many diverse systems developed by the Departments of Defense, Energy and the National Aeronautics and Space Agency (NASA), including DARPA. The analysis discussed in more detail later in this report include spectral density analysis of cost overrun data to develop logical aggregations within the overall data base. Based on statistical analysis of these data subsets, trends relating probabilistic measures of cost growth and uncertainty were developed. These trends displayed a remarkable consistency for all data sets under a variety of analytical assumptions. The analysis shows that based on historical evidence,

*cont'd*

cost overruns of significant size (from 50 to 100 percent) are not uncommon. In addition, the analysis shows that there is a predictable relationship between the size of an original estimate of program overrun (i.e., management reserve) and the confidence level that eventual cost growth will remain within that limit. For the initial set of DARPA programs studied, the analysis indicates that, at the 95 percent confidence limit, DARPA cost growth factors (i.e., the ratio of actual program costs to original estimates) lie in the range of approximately 40 to 110 percent. The analysis also permits management to estimate, in the aggregate, what total program management reserves should be as a function of confidence limit.

It is noted that caution should be used in the application of this preliminary analysis to current or future DARPA programs. Limitations imposed by the size and nature of the data base, and by a still limited understanding of the causal nature of cost growth and risk, make it unadvisable to attempt to immediately adopt these results as a tool for DARPA management. Nevertheless, the results so far do suggest that further study may lead to the development of a procedure for improving the accuracy, credibility, and defensibility of DARPA cost estimates and management reserves. The following section provides a more detailed discussion of these results.

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## II. TECHNICAL RESULTS

### Cost Growth Risk Assessment and Prediction for DARPA Programs

- o Examine broadest possible high technology data base for actual cost growth information
- o Develop rational aggregations of the data base and search for consistent statistical trends
- o Relate available DARPA program data to broad-based trends
- o Establish cost growth risk relationship(s) from broad data base that are both statistically and rationally applicable to the DARPA experience and environment.

## DATA BASE CORRELATION

- o Dimensionless "cost factors" used for graphical correlation and visualization.
- o "Estimated Cost Growth Factor" is the ratio of the estimated increased total cost (baseline cost plus cost growth estimate) to baseline (initial) total cost.
- o "Cost Growth Risk Factor" is the ratio of the statistically established probable cost growth (to some level of probability) to baseline cost.
- o The 45° line of figure 1 represents a "perfect" cost growth estimate, the dashed "Cost Growth Risk" line represents the statistically established potential deviation from the "perfect estimate".
- o The vertical distance from the "Perfect Estimate" line to the "Cost Growth Risk" line is a measure of the additional cost risk inherent when the "estimated cost growth" is anticipated.
- o The slope of the "Cost Growth Risk" line will be determined by statistical analysis of actual DOD-DOE and NASA cost growth experience for FY '77, '78, '79 and '80, correlated with all similar available DARPA data.

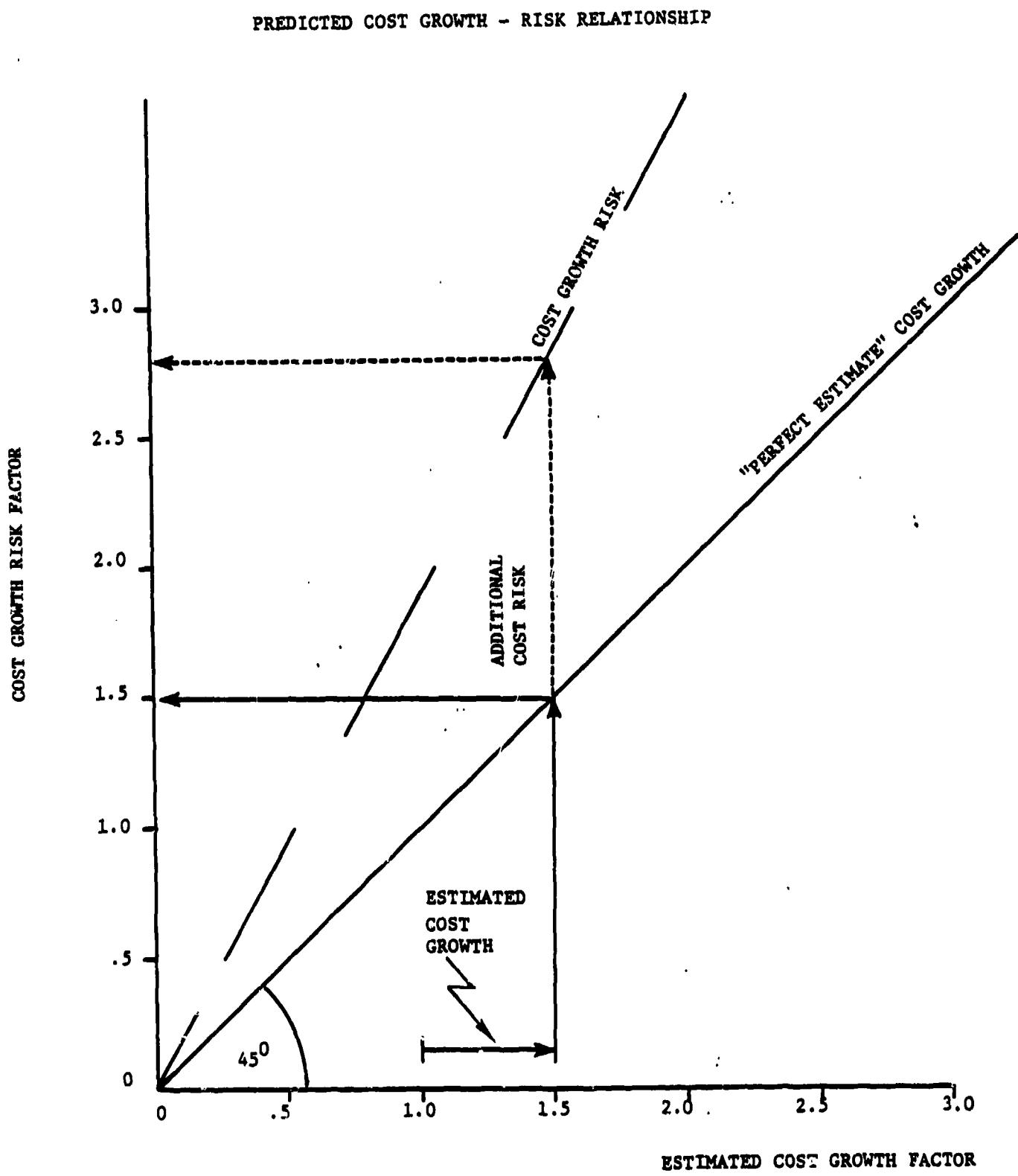


Figure 1

## STATISTICAL PROCESS

- o The DOD-DOE-NASA data base of actual cost overrun experience was aggregated into statistical groupings by both spectral density analysis and fiscal year groups of cost growth factors (actual cost over estimated cost).
- o The mean value and standard deviation were established for each group or aggregation of cost growth factors using the statistical standard distribution.
- o The cost growth risk line was established for these data at the mean of the two-standard-deviation (2-sigma) values for the established groupings.
- o The process was repeated for DARPA data, resulting in figures 2 and 3 wherein each square is represented as "2-sigma" long to a side, with the mean cost growth factor value at the lower left hand corner.
- o Figure 2 presents DARPA data grouped by spectral density analysis and figure 3, grouped by fiscal year. The dashed line in each case is the DOD-DOE-NASA "Cost Growth Risk" boundary.

DARPA PROGRAM COST GROWTH RISK  
(Spectral Density Grouping)

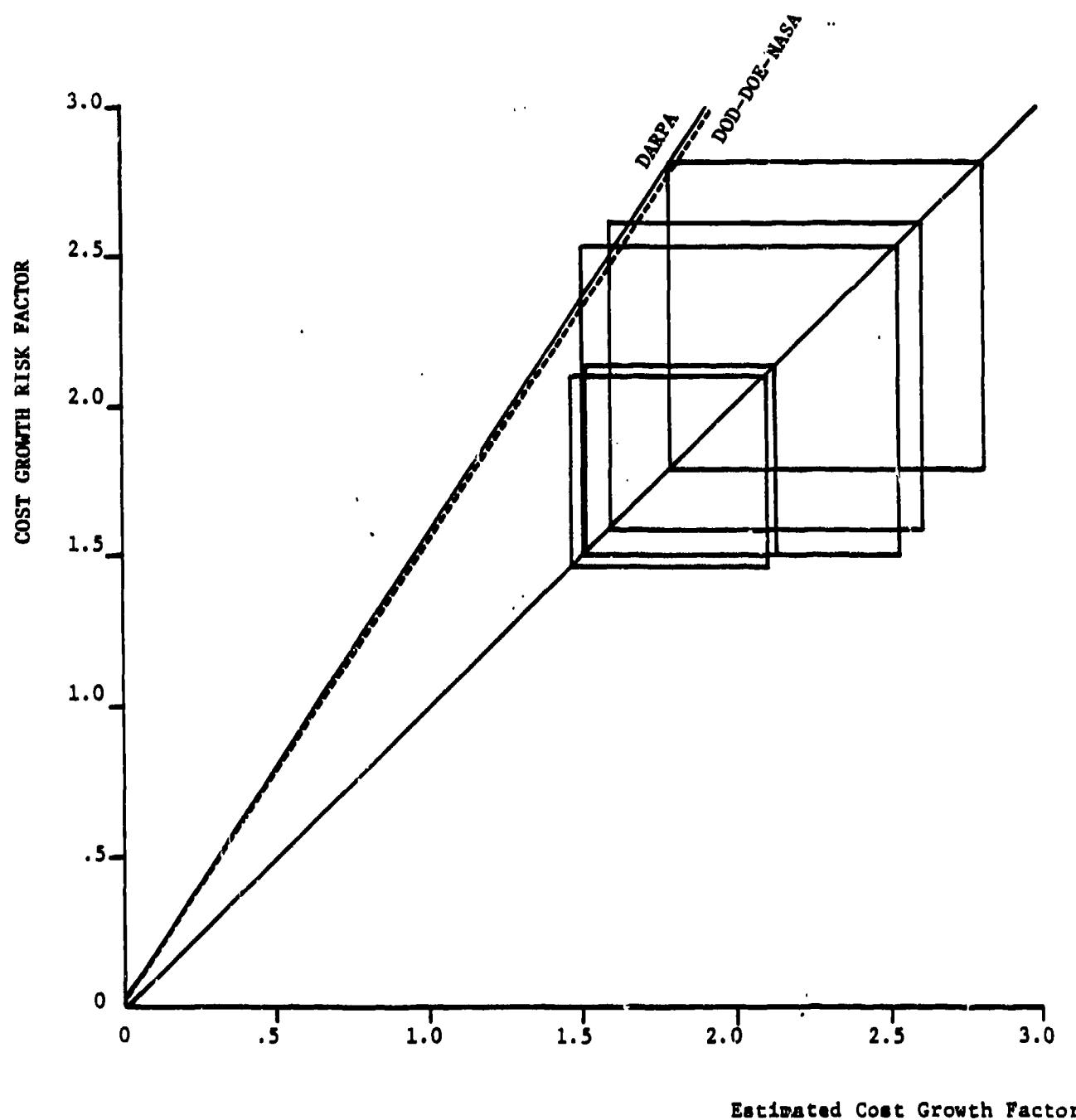


Figure 2

DARPA PROGRAM COST GROWTH RISK by YEAR  
(Fiscal Year Grouping)

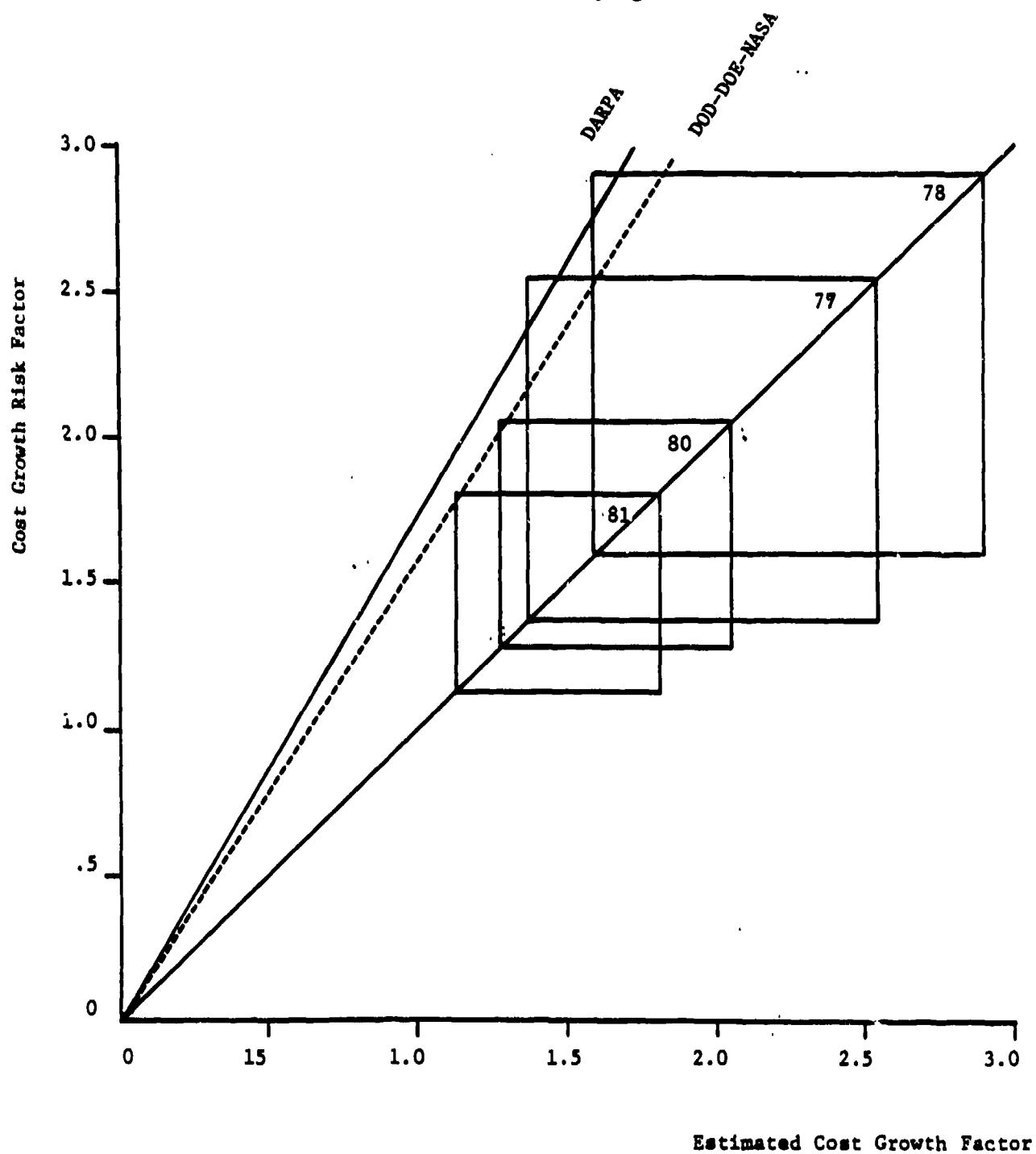


Figure 3

CONFIDENCE LEVELS  
AND MANAGEMENT RESERVES

- o Figure 4 was developed by taking the mean DARPA cost growth risk slope from figures 2 and 3, reapplying the statistical standard distribution, and establishing "bench mark" levels of confidence of cost overrun avoidance.
- o Tables 1 and 2 illustrate a preliminary and basic application of these confidence levels in determining the amount of management reserve which must be set aside to reach the various levels of confidence of cost overrun avoidance for specific DARPA programs.
- o Tables 1 and 2 are meant to be merely demonstrative, in a simplistic manner, of one mode of application of the actual experience data base. Further development will result in the refinement of this analytical tool and its synthesis with other methodologies into an integrated cost and cost-risk management system.

DARPA COST RISK RESERVE DISTRIBUTION

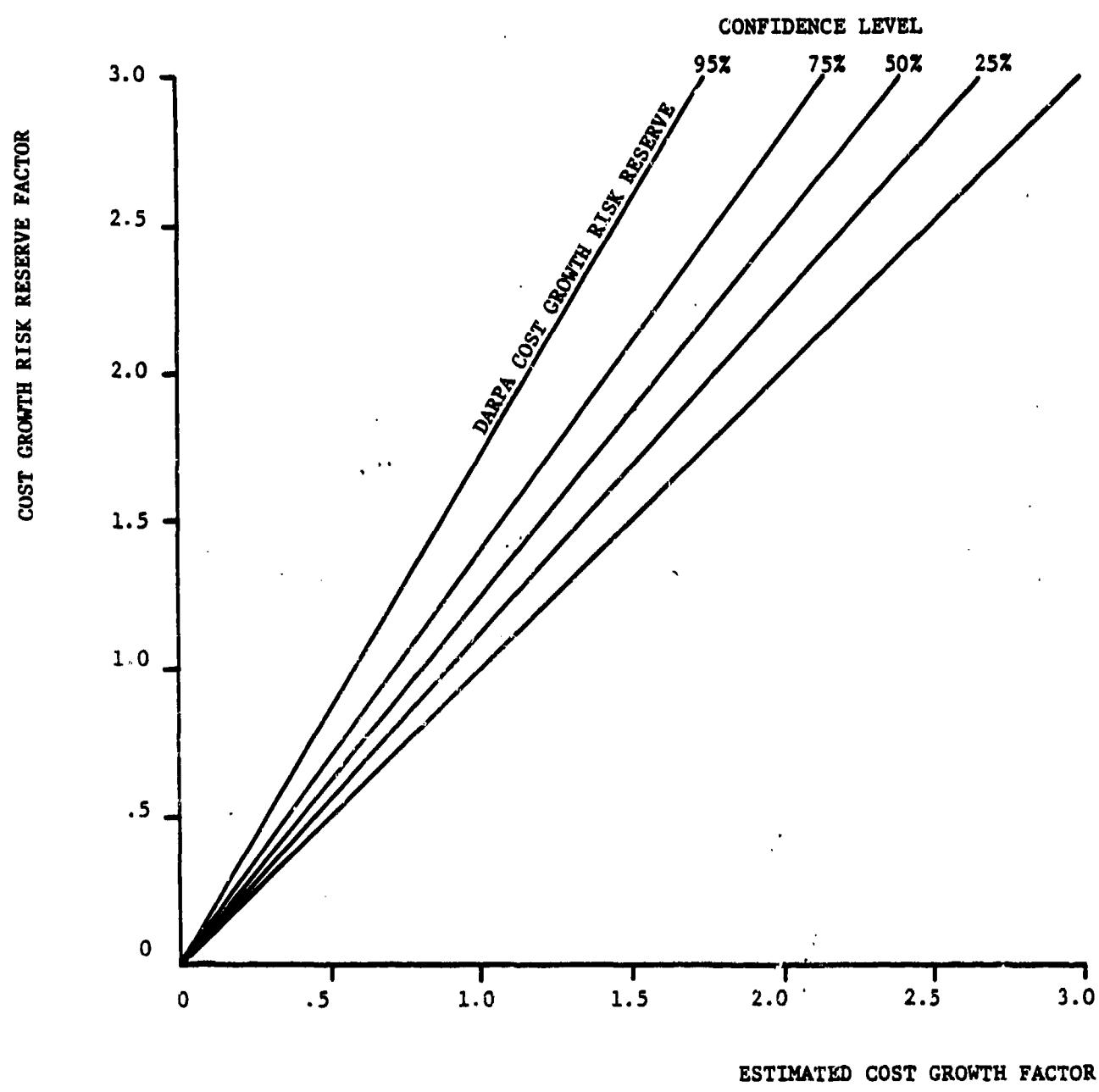


Figure 4

TABLE I

## DARPA POM-83 RDT&amp;E PROGRAM SUMMARY

FY 92 Budget (\$ in Thousands)  
 Management Reserve Requirement Option

PROJECT NUMBER	TITLE	BUDGET	CONFIDENCE LEVEL/RESERVE		
			2%	5%	7%
EE-2	TEAL RUBY Experiment	20,200	3,434	7,272	12,322
EE-6	Adv. Sensor Demonstration	40,800	6,936	14,688	24,888
EE-7	TALON GOLD Experiment	25,800	4,386	9,288	15,738
EE-8	High Power Chemical Laser Ground-Based Demo - ALPHA	22,500	3,825	8,100	13,725
EE-9	Forward Swept Wing Demo	21,500	3,655	7,740	13,115
EE-10	Assault Breaker Demo	29,350	4,990	10,566	17,904
EE-12	Large Optics Demo Exp - LOX	12,200	2,074	4,392	7,442
EE-14	Tank Breaker	24,000	4,080	8,640	14,640
EE-16	Submarine Laser Communications	20,700	3,519	7,452	12,627
	TOTALS	217,050	36,899	78,138	132,401
					230,073

TABLE II

**DARPA POM-83 RDT&E PROGRAM SUMMARY**  
**FY 83 Budget (\$ in Thousands)**  
**Management Reserve Requirement Option**

PROJECT NUMBER	TITLE	BUDGET	CONFIDENCE LEVEL/RESERVE		
			25%	50%	75%
EE-2	TEAL RUBY Experiment	17,200	2,924	6,192	10,492
EE-6	Adv. Sensor Demonstration	64,300	10,931	23,148	39,223
EE-7	TALON GOLF Experiment	33,500	5,695	12,060	20,435
EE-8	High Power Chemical Laser Ground-Based Demo - ALPHA	21,000	3,740	7,920	13,420
EE-9	Forward Swept Wing Demo	26,500	4,505	9,540	16,165
EE-10	Assault Breaker Demo	---	---	---	---
EE-12	Large Optics Demo Exp - LODE	14,000	2,380	5,040	8,540
EE-14	Tank Breaker	14,000	2,380	5,040	8,540
EE-16	Submarine Laser Communications	31,200	5,304	11,232	19,032
<b>TOTALS</b>		<b>222,700</b>	<b>37,859</b>	<b>80,172</b>	<b>135,847</b>
					<b>236,062</b>